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CONTENTS

A Physiological and Biochemical Basis for Research on Fungi ... *David Godden* 339

Notes on Three Septic Adirondack Soils ... *M. J. Thirumalachar* 346

The Use of Embryological Formulas in Plant Taxonomy ... *Theodor Just* 351

Sierra Tacuichamona—A Shasta Plant Locale. ... *Howard Scott Gentry* 365

Najas arguta in Central America and Its Relations ... iana ... 371

Notes on Trifolium ... 377

The Evaluation of Some Taxonomic Characters in Cl... sia with a Key to Species and Varieties—II. ... 381

Torreya ... 393

A Catalog of Illinois ... (*Review*). *Philip* ... 394

Proceedings of the Club. ... 395

Index to American Botanical Literature ... 399

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BULLETIN OF THE TORREY BOTANICAL CLUB
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A PHYSIOLOGICAL AND BIOCHEMICAL BASIS FOR RESEARCH ON FUNGICIDES

DAVID GOTTLIEB

The necessary relationships between the lethal or static effects of some chemicals on fungi and the physiological and biochemical reactions of these organisms are often overlooked in the development of new fungicides. Yet a knowledge of these processes might furnish a rational basis for research on fungicides. A substance must have many specific properties to be an efficient toxin for fungi and these properties will vary with the commercial purpose for which the chemical is used. Nevertheless, one primary attribute is common to all fungicides no matter what their use; the chemical must be detrimental to the fungus. Most often, this is accomplished by preventing spore germination, sometimes by preventing growth or by the destruction of the mycelium, and it is possible that occasionally the prevention of reproduction could check the spread of the fungi.

Current techniques for the discovery of new fungicides are mainly empirical and are largely a matter of trial and error. The net is spread wide in the search for new toxic compounds and almost any chemical which is available is tested. Sometimes each new chemical which is produced in industrial laboratories is assayed for fungicidal properties as a matter of general routine. At other times the direction of research is guided by the nature of an industry's by-products in an attempt to find a use for such materials. Often the known toxic properties of chemicals toward other organisms such as bacteria and insects determine the types of materials which are synthesized. When a compound with good fungicidal properties is found, the efforts of the research group are intensified toward the production of its homologues and analogues, in a search for greater fungicidal power and for other properties. Many such related compounds are then synthesized to discover the functional groups in the molecule which are responsible for its toxicity. Attempts have been made to correlate the structure of organic compounds with their toxicity in the hope of discovering means of predicting the toxic properties of a chemical. Until now this goal has not been realized and such relationships between structure and toxicity remain unknown for the most part. Slight changes in a molecule often greatly alter its fungicidal properties, and the combination of two toxic groups in a compound might not only fail to increase its toxicity, but might even decrease it.

What are the reasons for our dependence upon purely empirical methods in the search for more efficient fungicides? One of these factors has been the

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paucity of information available on the physiology of the fungi. This void in our knowledge of the intimate life processes of the very organisms which we are seeking to attack has forced the investigator in the past to rely upon general protoplasmic toxins, such as the copper and mercury compounds, which were supposed to precipitate proteins (12); but even with these the nature of toxic activity remained a mystery. To fill the gap and allow a reasonable approach to the fungicide problems, attention should be directed to the fundamental structure and metabolic processes of the fungus. Horsfall and Zentmeyer (10) adopted a rational approach of this type for the study of fungicide activity. They determined a number of generic compounds which normally occur in all cells, and then tested the toxicity to fungus spores of various reagents which are used for the analysis of these materials. These reagents were found to possess good fungistatic properties. A more exact knowledge of the fungus is, however, necessary to make such studies fruitful. Interest, as far as possible, should be centered not only on the characteristics common to all living cells, but also upon their specific modifications and biological transformations within the fungus. What is sought in agricultural sprays and dusts are materials which injure the fungus spore while not materially affecting the host plant. Differences in physiology between host and pathogen are important and it is upon the presence of such differences that the ideal fungicide, which is not injurious to the host plant, will be synthesized.

Attention should be directed especially to the spore, if protectants against fungi are sought. The purpose of most fungicides is to prevent the entrance of the fungus into the host or the production of mycelium, by inhibiting the germination of the spores. Too often germination is considered merely as an absorption of water resulting in the dilution of the protoplasmic elements of the spore with a consequent swelling of the cell to produce the germ tube. This interpretation would be analogous to the swelling of colloidal substances in contact with water. However, germination is a more delicate and dynamic process. Even before any visible sign of a germ tube is evident, respiration takes place in the spore (15). The metabolic processes function even in this early stage of development and food reserves of the cell furnish energy and material for growth. Some spores, such as those of *Sclerotinia fructicola*, require an external source of carbon such as dextrose or alcohol for germination (13). Very low concentrations of mineral salts at times enhance the germination of spores, and antagonistic effects of different salts have been recorded. The presence of many of the physiologic processes normally associated with growth is thus indicated in the spore, before growth is microscopically evident. Specific compounds for disturbing such processes would then be the goal of fungicide research.

Information on the composition of the cell wall and the cell membranes, and on their permeabilities, could also be valuable in the synthesis of fungi-

cides. It would provide the data for the synthesis of organic chemicals which contain the proper balance of hydrophilic and hydrophobic groups, to insure the passage of the toxic molecules through the cell membranes and their arrival at the seat of specific protoplasmic activity.

Recent investigations on the therapeutic activity of 8-quinolinol in the wilt diseases (21) indicate the importance which a knowledge of the mineral nutrition of the fungus can play in the treatment of diseases. When 8-quinolinol was added to the medium the growth of *Fusarium oxysporum* f. *lycopersici* was inhibited; but when an excess of zinc was added, the *Fusarium* grew well. The explanation was proposed that the zinc is necessary for the growth of the fungus and that it is precipitated by the reagent, thereby depriving the fungus of an essential element.

Another area of knowledge in which our information of the fungi is limited is the vitamin requirements of these organisms and their role in the respiratory and metabolic mechanisms. Except for vitamin B_1 and biotin little information is available on the fungal relationships of the other coenzymes, though some studies have been conducted on riboflavin. The fat-soluble vitamins also have been neglected. Information on the vitamins essential to fungi, whether synthesized by the organism itself or obtained from its nutrients, could play an important part in furnishing valuable clues for the synthesis of fungicides. Altering the structure of a vitamin to produce analogues of that compound sometimes converts the material into an antivitamin which inhibits the growth-promoting activity of the original compound. Robbins (17) showed that pyrithiamine, the pyridine analogue of thiamine, inhibited the growth of some fungi. The substitution of a dulcityl for a ribityl group in the molecule of riboflavin converts the compound into galactoflavin, which inhibited the growth of rats (2). Other analogues are known to have antivitamin properties for animals (3). Merely supplying an adequate excess of the vitamin usually overcomes the detrimental effects of an antivitamin (20). Such relationships may exist for vitamins still unknown but peculiar to some fungi. If their presence in fungi were ascertained, one direction of fungicide research could be the development of antivitamins for use as fungicides. Unpublished studies by the writer have indicated the absence of vitamin C in some fungi, yet this vitamin occurs in most plants. Might not the converse of this occur and a vitamin be found which is essential to and manufactured by the fungus but not essential to its host? Such a relationship would furnish a target at which the research for therapeutic agents as antivitamins could be directed. Then, if an inhibitor for this growth promoter was found it could be injected into the host and prevent the growth of the fungus while not disturbing the metabolism of the host plant.

The enzyme systems of the fungi also deserve more intensive study.

Many of the hydrolyzing enzymes have been identified but, except for the yeasts, information on the respiratory enzymes is very scarce. The specificity of enzyme poisons is very acute and such toxins can even selectively inhibit different respiratory enzymes in the same system. Potassium cyanide and sodium azide will block the activity of the cytochrome oxidases, while phenyl urethane and amyl alcohol inhibit the dehydrogenases (12). It is probable that the activity of many of our bactericides and fungicides is due to their ability to combine with an enzyme and so inhibit its activity. Even the activity of the mercury compounds, whose fungicidal properties have been attributed to their precipitating action upon proteins, may instead be specific enzyme inhibitors. An intimate investigation of the bactericidal effect of such compounds (4) has revealed that the toxic activity of mercury compounds could be prevented by the addition of the omnipresent tripeptide, glutathione, and indicates that mercury plays a more specific role in interfering with the oxidation-reduction mechanisms of the living cell than is sometimes considered. Hellerman, Chinard, and Dietz (8) showed that organic mercurials combined with the sulfhydril groups of urease and inhibited its activity. Another mode of action of a fungicide could be its competition with an enzyme for some essential metabolite, or with an essential metabolite for an enzyme itself, as has been indicated for the bacteriostatic action of the sulfanamide drugs which compete with p-amino benzoic acid (16). Enzyme systems have a vital function in almost every life process. One of the most vulnerable systems and the one about which more information is available than any other is the enzymes of intermediate carbohydrate metabolism. This chain of degradation can be blocked at many points. Information of the paths of degradation of glucose in both the pathogenic fungi and their green host plants (and many possible paths are known) would indicate whether such differences could be utilized by specific enzyme poisons to block the respiration of the parasite and not impair the vigor of the host. A knowledge of the enzyme systems may be useful in a still different manner. Instead of hindering the activity of such systems, therapeutic advantage might even be obtained by promoting an enzyme process (14).

Recent developments in the field of antibiosis have indicated another approach to the development of fungicides which is dependent upon our knowledge of the biology of the organism. Some of the antibiotics, such as clavacin (5, 11) and gliotoxin (19) are toxic to fungi. Brian and McGowan (1) recently isolated a new compound from *Trichoderma viride* which is one hundred times more toxic to spores of *Botrytis allii* than is mercuric chloride. Studies on the structure of the antibiotics to reveal the particular group responsible for their fungistatic activity, and their mode of action, could indicate types of synthetic organics which might be even more toxic than their naturally occurring homologues. Geiger and Conn (5), for ex-

ample, observed that both clavacin and penicillic acid contained an α, β unsaturated ketone, a grouping which readily combines with sulfhydril groups. The knowledge that these antibiotics were also inactivated by cysteine led the investigators to the hypothesis that synthetic organic chemicals of similar structure should be good fungicides. Several such materials were found, of which acrylophenone, benzalacetophenone, and furfuralacetophenone proved effective, and also reacted with sulfhydril groups. Acrylophenone especially had marked fungistatic power, with an activity in the same order as clavacin.

Many other physiological factors, either chemical, physical, or their combination in the fungi, deserve closer study. Very little is known of the electric charge on a spore. Studies by Seifriz and Gottlieb (18) on the cataphoretic behavior of spores indicated differences between *Sclerotinia fructicola* and *Fusarium oxysporum* f. *lycopersici*. Such differences might influence the behavior of charged organic fungicides and determine the relative effectiveness of particular fungicides such as the cationic quaternary ammonium compounds against spores of two species. The redox potentials in fungi have received little scrutiny, yet they are of utmost importance in the energy transformations of the cell. The efficiency of one fungicide, Spergon (tetrachloroquinone), an excellent seed treatment, has been linked to its oxidative properties (9). Attention should also be focused on the surface phenomena in these microorganisms and the effect on the spore of various reagents which alter surface tension.

One of the puzzling phenomena encountered by plant pathologists is the specificity of fungicides. In the laboratory assay this specificity is expressed as differences in concentration of a chemical which is necessary to inhibit spore germination of different species. Often the concentration of chemicals required to inhibit germination of *Macrosporium sarcinaeforme* is as much as sixteen times that required to inhibit *Sclerotinia fructicola*. This phenomenon cannot be entirely explained by the large size of the spore of the former compared to that of the latter, for occasionally the converse occurs and a greater concentration of another material is necessary to inhibit *S. fructicola* than *M. sarcinaeforme*. *Glomerella cingulata*, with small spores, is relatively tolerant to hydrogen sulfide, while the larger spores of *S. fructicola* are very susceptible (9). Similar differential effects of protective sprays on two pathogens have been reported in field studies. This sometimes occurs even when both pathogens are parasites of the same host. A recently developed fungicide, zerlate (zinc dimethyldithiocarbamate), very efficiently controls the early blight of potatoes but is only moderately effective against late blight of potatoes (7). Do some fungi possess protective reactions against toxins, such as have been demonstrated for animal tissues? The tolerance of a fungus to a particular chemical could be due to its ability to oxidize, to

reduce, or to combine the toxicant with some normal constituent of its protoplasm. It might thereby form an innocuous substance which can be metabolized or eliminated by the organism. The mammalian body makes use of all three protective devices; cyclohexane is oxidized to adipic acid, quinone is reduced to hydroquinone, and benzoic acid is conjugated with glycine to form hippuric acid (6).

The emphasis on fundamental studies in the physiology and biochemistry of the fungi as an aid to fungicide development is not proposed as an alternative method to the current empirical research. It is suggested, rather, as a guide for such investigations into areas of biochemical reactions which are concerned with the vital processes of the fungus and where the empirical methods could be most effectively employed. In addition, fundamental studies of the living organism can furnish clues on the type of organic molecule which effectively inhibit the biochemical reactions necessary to the life of the organism. Finally, such research can put plant protection on a basis of rational scientific principles.

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NOTES ON THREE SOUTH AFRICAN RUSTS

M. J. THIRUMALACHAR[1]

Some collections of rusts were received by the writer from the Mycological Herbarium of the Union Department of Agriculture, South Africa, through the kindness of Dr. A. M. Bottomley and Dr. E. M. Doidge. Before the material was incorporated in the writer's herbarium a brief study of it revealed certain interesting features. Observations pertaining to three of the rusts included in the collections are presented in this paper; they refer either to finding of new spore forms unrecorded in the original description of the species, or to the identity of the rust based upon the morphology of the spore forms as interpreted by the writer.

(1) A rust collection on *Grewia monticola* Sond. was sent to the writer tentatively identified as *Ravenelia atrides* Syd. (U.D.A. No. 32401). The type of *Ravenelia atrides* was collected by Pole Evans from South Africa on the leaves of *Grewia caffrae*, and is of interest on account of the fact that it is the only species of *Ravenelia* to parasitize a member of the Tiliaceae; most of the other species of the genus are parasitic on Euphorbiaceae or Leguminosae. While an authentic specimen of *R. atrides* was not available for study, a detailed examination of the specimen sent to the writer revealed that it was not congeneric with *Ravenelia* and therefore warranted restudy. Small bits of the leaf containing the sori were softened and embedded in paraffin, and good microtome sections were obtained. The sections were stained with Delafield's haematoxylin and permanent mounts were made.

The uredia are minute, sparsely distributed, erumpent, and pulverulent. They are paraphysate, the paraphyses marginal and incurved. The urediospores are ovate-ellipsoid, cinnamon-yellow, 20–26 × 15–20 μ. The epispore is hyaline, minutely and densely verruculose with indistinct germ pores (fig. 2). The telia are developed either in place of the uredia, in which case the marginal row of paraphyses is retained, or separately, in which case they are aparaphysate. In a young telium the teliospore mother-cells are grouped deep within the mesophyll tissue. These mother cells abstrict in basipetal succession chains of one-celled teliospores which adhere permanently both vertically and laterally to form a compact columnar crust. The apex of the teliospore head becomes expanded to form a flabelliform structure (fig. 1). These cushion-like heads of telia are usually single in each telium but very

[1] This paper was transmitted to the editor through the kindness of Dr. George B. Cummins, of Purdue University. In order to avoid long delay in publication, he has also cooperated in the reading of the proof and in certain minor editorial changes.

rarely more than one occurs in each sorus. They are approximately 130–167 μ high, 130 to 154 μ broad at the apex, and about 83–90 μ broad at the base of the telial head. The mature spores are sessile, one-celled, developed in catenations in basipetal succesession, yellowish-brown, smooth and measuring 11.5–21 × 8–12 μ. The apex of the terminal spores in the chain is thickened. In addition to the compact grouping of the teliospores, a thin layer of hyphal sheath (fig. 3) is found enveloping the telial crust which is found to impart rigidity and to retain the shape of the telial head. The structure of the telium clearly indicates that the rust is congeneric with *Dasturella*, recently described by Mundkur and Kheswalla (1943). The genus is characterized by subepidermal paraphysate uredia, the paraphyses being cylindric and incurved; and by possessing telia which are subepidermal, erumpent, with

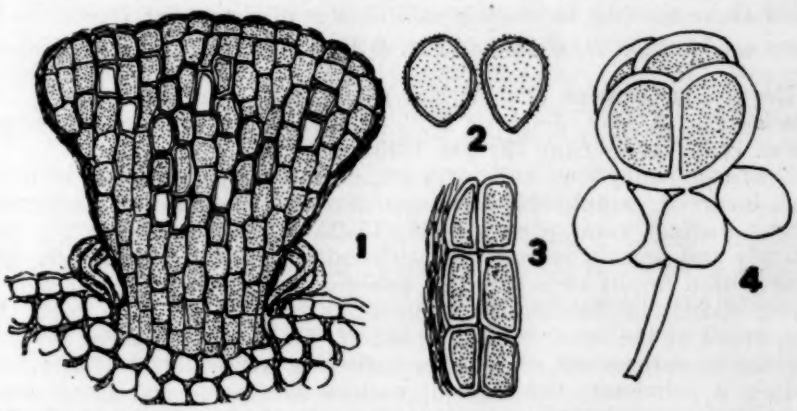

FIG. 1. Telium of *Dasturella Grewiae*. × 300. FIG. 2. Urediospores of *D. Grewiae*. × 500. FIG. 3. Margin of a telium of *D. Grewiae* showing the hyphal sheath which surrounds the telium. × 500. FIG. 4. Teliospore head of *Spumula Bottomleyae*. × 500.

teliospores fascicled into large flabelliform crusts. Only two species are known for the genus so far, both of them leaf-parasites of bamboo. From a study of the structure of the uredium and telium, the South African rust on *Grewia monticola* is doubtless a species of *Dasturella*.

From a specimen collected by Chevalier on *Grewia* sp. near Senegal, Africa, Cummins (1945) has recently described *Phakopsora Grewiae* (Pat. & Har.) Cummins as the perfect stage of *Uredo Grewiae* Pat. & Har. A small fragment of Doidge's collection of the *Grewia* rust (No. 32401) was sent by the writer to Dr. Cummins with the writer's remarks that it is a species of *Dasturella*. Through his kindess it was made known to the writer that the South African rust on *Grewia monticola* is identical with the Chevalier's collection studied by him and would therefore constitute the perfect stage of *Uredo Grewiae* Pat. & Har. It becomes clear, however, from the characters of the telia, that it is not a typical *Phakopsora*.

In the description of the genus *Dasturella*, Mundkur and Kheswalla (1943) state that the teliospores appear not to be one-celled and catenulate but are continuous structures composed of 3–6 superposed cells. This indicates that all the cells in a vertical row are of the same maturity. However, a study of the type of the genus, *D. divina* (Syd.) Mundkur & Kheswalla, obtained from the Herb. Crypt. Ind. Orient., and of fresh specimens collected in Mysore indicated that the spores in a vertical row are of different maturity and that new spores are added from the base in basipetal succession. Consequently the spores are one-celled and catenulate. The genus is distinguished from *Angiopsora* Mains in having an erumpent telium which is naked and flabelliform, as against the non-erumpent, lenticular telial crust of *Angiopsora*. On account of the possession of the characters mentioned above the rust on *Grewia monticola* is placed under *Dasturella* and a new combination *D. Grewiae* (Pat. & Har.) Thirumalachar is proposed.

Dasturella Grewiae (Pat. & Har.) Thirumalachar, comb. nov. *Uredo Grewiae* Pat. & Har. Jour. de Bot. **14**: 237. 1900; *Phakopsora grewiae* Cumm. Bull. Torrey Club **72**: 206. 1945.

Uredia hypophyllous, subepidermal, erumpent, pulverulent, with marginal, incurved paraphyses; urediospores ovate-ellipsoid, cinnamon-yellow, without distinct germ pores, 20–26 × 15–20 μ; epispore about 1 μ thick, minutely and densely verruculose, with indistinct germ pores. Telia developing within uredia or separately, subepidermal, erumpent and soon becoming naked, in flabelliform cushion-like crusts, 130–167 μ high, 130–154 μ broad at the apex, 83–90 μ broad at the base; teliospores developed in basipetal catenations, the spores coalescing vertically and laterally to produce a columnar, flabelliform, cushion-like head, one-celled, sessile, yellowish-brown, ovate to cuboid, moderately thick-walled, smooth, 11.5–21 × 8–12 μ.

On the leaves of *Grewia monticola* Sond., Experimental Station, Kelspruit, Tvl., South Africa, 2nd Aug. 1940 (U.D. No. 32401).

In her monographic studies on the South African rusts, a rust on *Albizzia versicolor* was described by Doidge (1926) as *Ravenelia Bottomleyae* Doidge, based on the collections made by Dr. Bottomley near Victoria Falls, S. Africa. The urediospores were noticed intermixed with the telia, being golden-brown, globose to ellipsoid, verruculate-echinulate, 30–42 × 25–27 μ. The telia are amphigenous, black, subepidermal, erumpent, and pulverulent. The teliospores are in pedicellate heads composed of 4–6 spores, the pedicels being very fragile. A portion of the type (U.D.A. 14166) was kindly sent to the writer by Dr. A. M. Bottomley, which made possible a study of the rust in some detail. The telial heads are mostly 6-spored, of which two are in the center and four are marginal. Occasionally, as noticed by Doidge also, there is only a single inner spore with two marginal spores. Mature spores are chestnut-brown, smooth, 27–30 × 25–33 μ. On each of the marginal spores, a single large, pendent, hyaline cyst

is present. These swell in water and can be clearly observed in spore mounts stained with a dilute solution of Gentian violet. The pedicel is simple, hyaline (fig. 4), long, deciduous. The pedicel is attached directly to the spore and not to the fused portions of the cysts.

The genus *Spumula* Mains was erected by Mains (1935) for a leguminous rust on *Calliandra*. The genus is closely allied to *Ravenelia* Berk. and *Cystomyces* Syd. but has greater affinity with the former than with the latter. *Spumula* is, however, differentiated from *Ravenelia* by the absence of a compound spore head with compound pedicel. It resembles *Cystomyces* in the possession of a simple pedicel, but the stipe of *Cystomyces* is attached to the fused portions of the cysts and not directly to the spore as in *Spumula*.

A similar condition prevails in the telial heads of the rust on *Albizzia versicolor*, in which the pedicels are simple and not compound, and the attachment of the pedicel is directly with the spore and not with the fused portions of the cysts. The simple pedicel has also been figured by Doidge (*l.c.*) which clearly differentiates the rust from *Ravenelia* and secures a place for it in *Spumula*, proposed by Mains. Only two species are known in the genus so far, *Spumula quadrifida* Mains, the type of the genus with aecia and telia, and *S. Clemensiae* Arth. & Cumm., recorded in the Philippines by Arthur and Cummins (1936); the latter is a hemiform with uredia and telia. It is evident that the rust on *Albizzia versicolor* is also a species of *Spumula* on account of the possession of the characters already enumerated. A new combination, **Spumula Bottomleyae** (Doidge) Thirumalachar is proposed for its accommodation.

Skierka robusta Doidge was described by Doidge (1926) as parasitic on the leaves of *Rhoicissus rhomboidea* from South Africa. Only telia were reported, the teliospores being yellowish, lanceo-fusiform with acuminate apex, and adhering to form short columns 3–5 mm. in length. In the collection of the rust sent to the writer (U.D.A. No. 6628), large numbers of pycnia were associated with the telia, indicating that the rust is definitely a micro-form, the telia immediately following pycnia in development. Pycnia are amphigenous, minute, orange-yellow, distributed in concentric rings. Sections through the infected patch indicates that the pycnia are subepidermal in origin, broader than long, 230–320 μ broad, 120–140 μ high, with a narrow ostiole. There are no conspicuous ostiolar hyphae projecting. Pycnia have been recorded also for two other species of *Skierka*, viz. *S. Holwayi* Arth. and *S. cristata* (Speg.) Mains (Mains 1939).

In conclusion the writer wishes to acknowledge his grateful appreciation for the kindness of Dr. G. B. Cummins, Purdue University, U. S. A., for the benefit of valuable suggestions, and to Drs. E. M. Doidge and A. M.

Bottomley, Union Department of Agriculture, South Africa, for placing at the disposal of the writer the valuable material. Grateful thanks are due to Dr. L. N. Rao, Professor of Botany, University of Mysore, for kind encouragement. This part of the work was carried out as a research scholar of the University of Mysore.

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THE USE OF EMBRYOLOGICAL FORMULAS IN PLANT TAXONOMY

THEODOR JUST[1]

Cytogenetic data, especially chromosome numbers, are now regularly recorded in many systematic studies and have even made their way into floras. The same cannot be said, however, with regard to the laboriously accumulated information often referred to as comparative embryology (Schnarf 1931, Maheshwari 1945). Johansen (1945) has advanced objections to such "an excessively broad" application of the term embryology, because in many instances megasporogeny and megagametogeny (or, if both are treated at the same time, simply megagametogeny) alone are implied to the exclusion of real embryogeny, which begins with syngamy. Recognizing the validity of these objections, the broad use of embryology, though embracing actual stages of two successive generations, is perhaps justifiable in the light of the somewhat comparable usage of it by zoologists, the absence of another equally inclusive term, and the characterization of all phases of "pure" plant embryology given by Johansen himself (1945).

The use of embryology sensu lat. is actually necessitated by the great variety of embryological phenomena described to date and the desire to bring these under some common heading (Schnarf 1929). As the purely descriptive phases of plant embryology are largely completed, even though many orders and families remain to be investigated, the accumulated data have and will continue to be variously applied in other respects. One of these applications is the utilization of embryological knowledge for the improvement of the existing classifications of angiosperms (Mauritzon 1939; Schnarf 1931, 1933, 1937). Obviously, this aim cannot be attained on the basis of a single embryological character, i.e., the development of the male gametophyte, but only by the simultaneous evaluation of all significant embryological features, as is usually the practice with gross morphological and other characters. Originally Schnarf (1933) proposed the term "embryological diagram" for the entire set of important embryological characters of any group. This proposal of utilizing as far as possible embryological diagrams for taxonomic purposes was recently restated by Maheshwari (1945), who adopted the preferable designation "embryological formula" and promptly

[1] The writer is greatly obliged to Drs. G. N. Jones, University of Illinois, and Paul Weatherwax, Indiana University, for their critical reading of his manuscript but is especially indebted to Dr. P. Maheshwari, Dacca University, Dacca, India, for his valuable suggestions and comments.

illustrated his views with a suitable example, the Alismaceae. The embryological formula of this family as drawn up by Maheshwari reads as follows:

"ANTH.–TAP. (amoeboid); DIV. OF P.M.C. (succ.); P. (3-nucl.); OVULE (2-integ.; anat.); PAR. CELL (absent); E.S. (*Allium* T.); END. (*He.* or *Nu.* T.); EMB. (*Sag.* T.)."

"Put in plain English this means that the anther tapetum is of the amoeboid type; the divisions of the pollen mother-cells are successive; the pollen grains are 3-nucleate at the time of shedding; the ovule is anatropous and has two integuments; no wall cell is cut off by the primary archesporial cell which functions directly as the megaspore-mother-cell; the embryo-sac development is of the *Allium* type; the endosperm is of the *Nuclear* or *Helobiales* type; and the embryo is of the *Sagittaria* type" (loc. cit., p. 32).

Fully aware of the possibility of greater condensation Maheshwari expressed the hope that a list of internationally acceptable symbols be developed and used both by students of plant embryology and classification. In the light of the great value generally attributed to "floral formulas" in discussions of plant relationships and in teaching plant taxonomy, the following list of symbols is tentatively proposed and their applicability demonstrated in several cases.

Other systems of annotation proposed solely for the characterization of the various types of development of embryo sacs, namely those of Chiarugi, Radermacher, Rutgers (summary in Schnarf 1929), and Fagerlind (1944) are not incorporated here, because of their detailed nature and the lack of complete agreement regarding the best method of designating the known types of embryo sac development. They are, however, very well suited for the careful description of embryo sac development, notably Fagerlind's last scheme.

At present only those sets of characters are included in the following list whose taxonomic usefulness has by now been established beyond doubt. As is most likely, other characters will be found in the future and suitable symbols for these can readily be added to the present list. The selected characters are those given by Schnarf (1931, 1933) and amended by Maheshwari (1945). The designations of the types of embryo sac development follow Maheshwari (1941).

T = anther tapetum Tg = glandular Ta = amoeboid Tp = tapetal plasmodium.
P = pollen; Psi = quadripartition of microspore mother cell by furrowing (simultaneous).
Psu = quadripartition of microspore mother cell by cell plates (successive).
/2 = two nuclei in pollen grain at time of discharge from anther, /3 = three, etc.
Ov = ovule; (Ov) = unitegmic (one integument), ((Ov)) = bitegmic (two integuments).
Ti = integumentary tapetum.

Ov = integument absent. ob = obturator.
c = crassinucellate t = tenuinucellate.
$\overline{Ov}$ = orthotropous . $\underline{Ov}$ = anatropous $O\hat{v}$ = campylotropous.
My = micropyle My/i = formed by inner integument My/o = by the outer integument My/2 = formed by both integuments.
Nu = nucellus Nu^{i} = integument begins near apex of nucellus Nu_{i} = near base.
hy = hypostase. Nu+ = nucellus with long beak-like process in micropyle.
Ar = archesporium one-celled Ar^{∞} = many-celled.
θ = parietal cell absent. ! = parietal cell present.
ES = embryo sac ESn = normal type ESoe = Oenothera type ESal = Allium type ESpp = Peperomia pellucida type ESph = Peperomia hispidula type ESg = Gunnera type ESpe = Penaea type ESpy = Pyrethrum type ESd = Drusa type ESac = Acalypha type ESf = Fritillaria type ESpa = Plumbagella type ESpo = Plumbago type ESad = Adoxa type.
S = syngamy po = porogamy ch = chalazogamy + = long interval between pollination and fertilization, exceeding one week.
E = endosperm Enu = nuclear Ece = cellular Ehe = Helobiales type Ehe/nu = Heliobiales or nuclear type.
Eh/m = micropylar Eh/c = chalazal Eh/m + c = micropylar and chalazal endosperm haustoria.
Em = embryo Emp = Piperad type Ema = Asterad type Emca = Caryophyllad type Ems = Solanad type Emo = Onagrad type Emch = Chenopodiad type Emsag = Sagittaria type.[2]
su = suspensor haustorium.
Ap = apomixis. Py = polyembryony. Pa = parthenogenesis.

Using these symbols the embryological formula of the Alismaceae reads as follows:

Ta, Psu/3, (($\overline{Ov}$))θ, ESal, Ehe/nu, Emsag.

The floral formula (Pool 1941, p. 101) by comparison reads:

$$\frac{CA^{3}Co^{3}S^{6-\infty}P^{6-\infty}}{PfMoDiAch}.$$

The species (3) of the aquatic genus *Trapa* have long been considered members of the family *Onagraceae* (Oenotheraceae). When it was found that the development of the embryo sac in this genus follows the normal type and that a well developed suspensor haustorium is present, it seemed even more out of place than it had been for other reasons, i.e., fruit. The embryological formula of the separate family established for this genus, the *Hydrocaryaceae* Raimann (Engler & Diels 1936) or *Trapaceae* (Pulle 1938), is as follows:

((Ov))c, Ar!, ESn, Em/su.

The embryological formula for the Onagraceae reads:

Tg, Ps/2, ((Ov))c, Ar!—Ar^{∞}, ESoe, Spo, Enu, Emo.

[2] Although Johansen (1945) points out that no essential differences exist in the embryogeny of the Dicotyledones and that of the Monocotyledones, it may be desirable to distinguish different types of embryo development in these groups, at least in view of the profound differences in later stages and seedling structure.

Obviously the life history of the Onagraceae is better known than that of the genus *Trapa*, a situation which accounts for the comparative brevity of the embryological formula of the genus *Trapa* as compared with that of the family Onagraceae. But it is evident that the removal of *Trapa* is justifiable on these as well as other grounds.

The position of the family *Cactaceae*, Order Cactales according to Bessey *et al.*, and its possible affinities have long been problematic. Hutchinson (1926) and Bessey (Pool 1941) placed it near the Cucurbitales, whereas Wettstein (1935) inserted it between the Aizoaceae and Portulacaceae. It must be remembered, however, that the order Centrospermae sensu Wettstein includes approximately the same families as Bessey's order Caryophyllales except the Salicaceae. To show the differences between the Cucurbitaceae and Cactaceae their respective embryological formulas have been determined and are herewith presented:

Cactaceae: Tg, Psi/3, ((O$\tilde{v}$))c, Myi, Ar!, ESn, S+, Enu.

Cucurbitaceae: Tg, Psi/2, ((Ov))c, Nu+, Ar!, ESn, Enu, Ap (?).

Several important characters can not be indicated in these formulas. The Cactaceae have a cavity in the chalazal part of the ovule between the two integuments and sometimes also between the inner integument and the nucellus. This cavity occurs in various families belonging to the Centrospermae. The Cucurbitaceae on the other hand develop a nucellus with a long, beak-like process extending into and often through the micropyle, here indicated as Nu+. The pollen tube develops characteristic haustoria which destroy the nucellar process in the micropyle. Morphological, anatomical, and chemical evidence supports the embryological similarity between the Cactaceae and Aizoaceae as well as other families of Centrospermae (Gibbs 1945).

Other instances of the applicability of embryological data in critical cases have been recorded and could readily be illustrated by the embryological formulas based on them (Maheshwari 1945; Mauritzon 1939; Schnarf 1933, 1937). Notable examples are the Liliaceae in the conventional sense and their modern segregates, the large order Synandrae (Campanulaceae, Lobeliaceae, Goodeniaceae, Compositae) and many others. The accepted orders of flowering plants may well be delimited differently, if embryological data are applied consistently, and groups which have so far not been investigated are studied embryologically. Therefore, the use of embryological data will be greatest as supplementary evidence in the improvement of our systems of classification, particularly with regard to the determination of the correct position and affinities of families and orders, whereas their application in purely descriptive works such as floras and manuals as well as in teaching elementary plant taxonomy may never prove feasible.

Embryological data need not be accorded more recognition than other

taxonomically valuable characters. They do, however, deserve their rightful place among the others, a position they have not yet attained in the eyes of all botanists.

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SIERRA TACUICHAMONA—A SINALOA PLANT LOCALE

HOWARD SCOTT GENTRY

In mid-Sinaloa Sierra Tacuichamona stands 4000 feet or more above the narrow coastal plain not far from the sea (fig. 1). It is volcanic in origin with a high central massif of brecciated lava flanked by rather deeply dissected ridges in considerable intricacy. Because of its stage of physiographic development and its structural similarity to neighboring mountains, its origin can be placed contemporaneously with the general foothill complex of northwestern Mexico, which arose at sometime in the Upper Tertiary. The whole is dynamically linked with the great Sierra Madre Occidental.

The great bulk of the mountain is covered with a climax virgin Short-tree Forest, persisting through 3000 or more feet of elevation. The general stature of the forest dominants is 35 to 40 feet. The spacing is regular and in the piedmont usually allows freedom of movement without a machete, while in the higher interior gradients a machete is often necessary. This forest as a whole is more tropical and expansive than the Short-tree Forest of the Rio Mayo to the north. The greater prevalence of epiphytes and indeed the whole tropical element appear engendered by the proximity of the ocean with its moist breezes.

Oak Forest occupies the summits and the higher slopes on the east in a rain shadow of the lee side (fig. 2). Its aspect is more arid than the Short-tree Forest. Oak Forest is an open broken member occupying elevations from 2000 to 4000 feet. Expanses of harsh-leaved grasses occur as well as numerous shrub populations, dispersed or in thickets. The leaf generally from grasses to composites is tough and scabrous and springs from a rocky shallow calcareous soil.

Savanilla is limited to a small area between the oaks and the Short-tree Forest on the north end of the mountain. This is an open formation on mild slopes with patches of trees and shrubs dispersed through turf-like grassland.

Thorn Forest and Pine Forest are both lacking. There is too much rainfall for the former. The lack of any appreciable highland appears to limit the pines to a few small clumps near the summits.

An interesting fauna accompanies this plant rich wilderness. Mountain lions and jaguars (*liones y tigres* to the natives) pad through the great canyons killing deer and cattle, and frightening men and their horses. Peccaries scuttle through the underbrush. Cholugos, *Nasua narica*, the long-nosed relative of the racoon, climb cliffs and trees, getting a relatively luxurious living from the wealth of roots and fruits. Among the many indigenous birds are

parrots, chanates, and two pheasant-like birds, the chachalaca and the much rarer "el faisan."

The Piedmont Forest. The plain around the west base of the mountain is covered with a uniform Short-tree Forest about 30 feet high. The trees are evenly spaced, and except for the light secondary covering of spindling

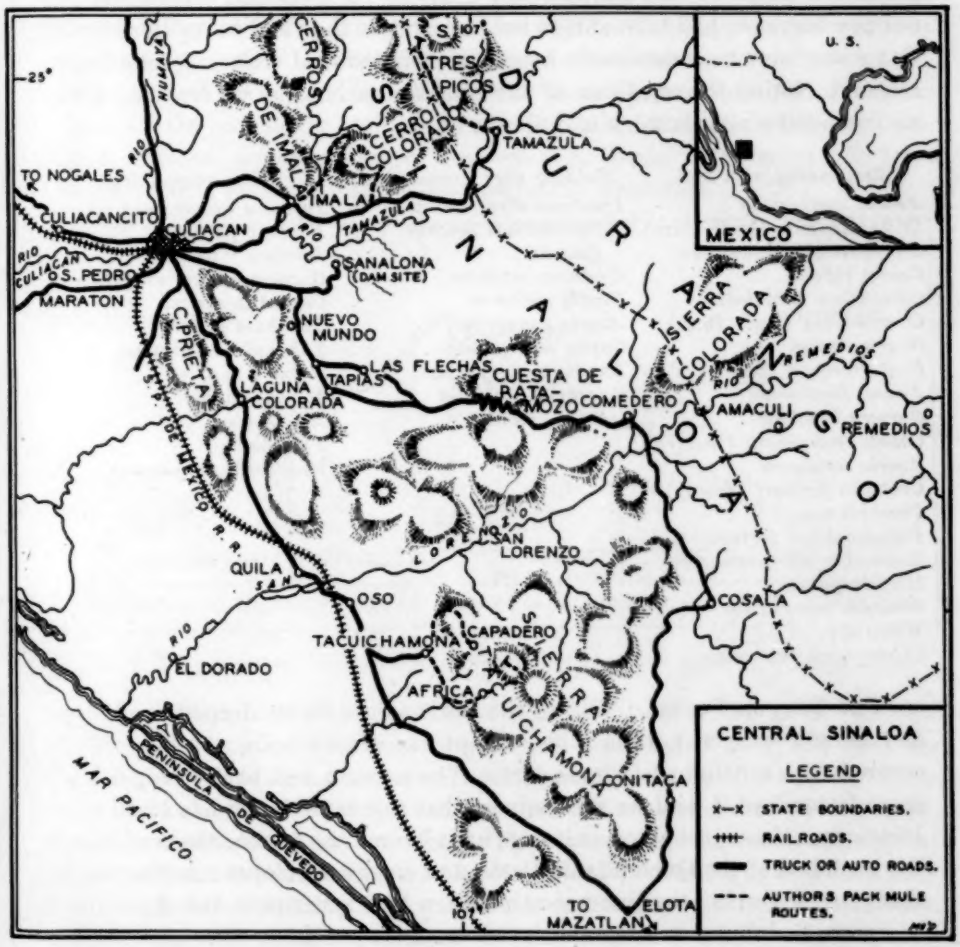

FIG. 1. Central Sinaloa, including Sierra Tacuichamona. 1: 250,000.

undershrubs, one has little difficulty in walking where he pleases. In mid-February when we passed through, the amapa, *Tabebuia palmeri*, was through flowering, long seed-pods hung from their leafless branches. The most conspicuous flowers were the strong bright yellows of *Cassia biflora* and *tecomosuche*, *Cochlospermum vitifolium*, the white of confite, *Lantana*

velutina, and the yellow-orange of *Lantana horrida*. Blooming then also but in less profusion were the cuajolote, *Bombax palmeri*, its huge white stamens standing out spread in the sun, the red-flowering vine compio, *Combretum farinosum*, a few palo santos, *Ipomoea arborescens*, still weekly putting out their white stars, and bacari, *Montanoa* sp. The vegetation was still rather green, for, following the winter rains, many of the trees and shrubs had put out new leaves or had been able to hold over those they had borne in summer. But many were too irrevocably bound to their habit of winter defoliation to respond. Noting the condition of the trees and shrubs as we traveled along we compiled a simple table as follows:

Responding with leaf	Holding over summer leaf	Not responding
Acacia cymbispina	*Lysiloma divaricatum*	*Ipomoea arborescens*
Croton fragilis (xeric form)	*Pithecolobium sonorae* (normal)	*Bombax palmeri*
Haematoxylon brasiletto	*Coutarea latiflora*	*Bombax* "batoco"
Cassia biflora	*Cordia alliodora*	*Cochlospermum vitifolium*
Caesalpinia platyloba	*Acacia pennatula*	*Conzattia sericea*
C. caladenia (xeric form)	*Cassia emarginata*	*Tabebuia palmeri*
C. eriostachys	*Randia* spp. (normal)	*Tabebuia chrysantha*
C. sclerocarpa (feebly)	*Guasuma ulmifolia*	*Bursera* spp.
Acacia farnesiana	"Isa" (feebly)	*Marsdenia* sp.
Bursera laxiflora		*Manihot* sp.
Cassia emarginata (feebly)		*Pereskia* sp.
Acacia cornigera		*Pedilanthus rubescens*
Crataeva palmeri (feebly)		
Prosopis spp.		
Pithecolobium tortum		
Euphorbia aff. *tresmariae*		
Mimosa palmeri		
Solanum amazonium		
Malva spp.		
Chlorophora tinctoria		

The Canyon Forest. Within the canyons the forest deepens and slope and narrow canyon bottom alike, except for arroyo beds, are bountifully covered with a delightful virgin forest. The axeman and bark-stripper have scarcely touched it, and we can suppose that this same forest has stood since Pleistocene times just about as it does now. From time to time the trail leaves the wash-bed of the Quebrada de Ilama and enters the slopes running under shady trees. During the summer rains when leaf is rampant the shade must be dense. Epiphytes are common upon the trees; orchids, *Tillandsia*, and a large coarse member of the Bromeliaceae. Lianas swing like huge, gnarled, and poorly twisted ropes from ground to limb, among them occasionally the perverted scandent form of *Pisonia capitata*. In places the canyon widens in the bottom and allows a "bottom-land" climax forest of unusual size and beauty. Its stature may reach 50 or 60 feet with isa, pochote, *Ceiba acuminata*, jauhuica, *Bursera arborescea*, manuta, *Lysiloma divaricatum*, and areyan, *Psidium sartorianum*, the principal dominants. Jauhuica is a

splendid tree branched only in the crown with its thick smooth branches bearing out a heavy spread of foliage mostly above the rest of the trees. Hecho, *Pachycereus pecten-aboriginum*, in such woods is successfully established, but less dominant than on the Coastal Plains, for the best it can do here is to elongate to something over half the general forest stature.

The Cliff Vegetation. On the rock outcroppings and cliffs the forest species still persist but thin out to make way for more xeric types, such as *Bombax* spp., *Cochlospermum vitifolium*, *Plumeria rubra*, *Agave* spp., *Ficus* spp., *Hechtia*, and an elephantine prostrate vulgarly called "inche huevos." On cool shady rocks occur a new *Hofmeisteria*, a *Dyospiros*, *Lysiloma watsoni*, *Lemaireocereus*, *Bursera* spp., ferns, *Euphorbia* aff. *tresmariae*, and a legion of others less frequently occurring.

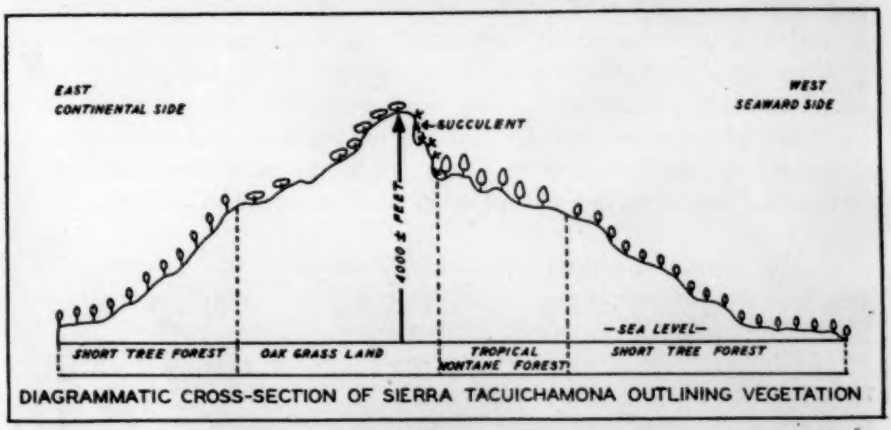

FIG. 2. Diagrammatic cross section of Sierra Tacuichamona outlining the vegetation.

Some Dominant Colonies. Near Rancho Africa, lying in the western canyons, a few species of trees form nearly pure stands or at the least are single dominants in such areas. The Mauutal[1] occupies hill swales with a stature of about 40 feet with trees well spaced, the sapling straight, elongate, and the undershrubbery very scant. The Apomal is a grove of magnificent tall slender trees, suggesting *eucalyptus*, about 70 feet high, branched only in a high crown holding heavy dark green foliage. It forms a clear open forest with scant undershrubbery. In the deep and usually steep-floored canyons these apomos, *Brosimum alicastrum*, form a dense shade. In such gloomy rocky glades grow only a few species of tropical shade-tolerant species; elongated, mesophytic perennial acanthaceous shrubs or herbs, the stinging huge-leaved *Urera caracasana*, the shrub *Phenax hirtus*, a few

[1] Stand of Mauuta trees, *Lysiloma divaricatum*. Native idiom provides names for many tree colonies by adding the suffix, *al* (or *l*). As ecologic terms they are very handy and can seldom be improved.

ferns, an entirely unexpected palm, *Chamaedorea*, and the attenuated otatillo rodillo, *Chusquea liebmanii*, whose graceful bamboo-like stems bend out in arcs 10 feet high or trail on other plants. *C. liebmanii* is here a remarkable northern extension in the previously known range of the genus. Epiphytic orchids are abundant on tree limbs. Often mixed with the apomos are a few other species of large trees, as juahuica, *Ficus*, *Prunus cortopico*, and bebelama de la Sierra.

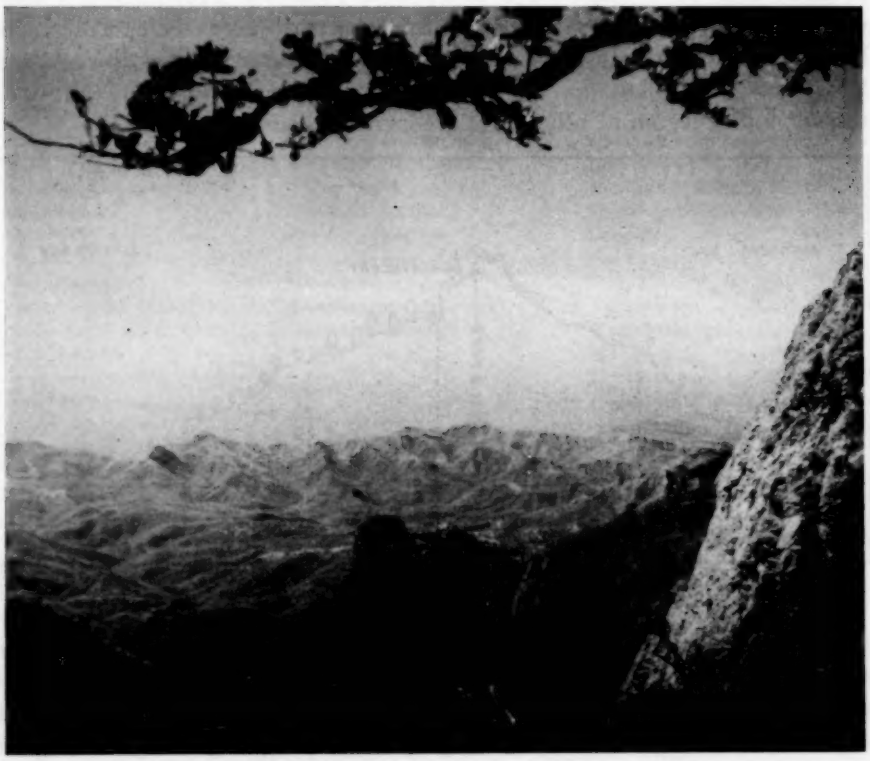

FIG. 3. View from the summit of Sierra Tacuichamona looking west to the Pacific Ocean, February 1941. Light patches draped on the hill summits are Oak Grassland.

Slope Forest. Shrubbery is exceptionally prevalent upon the slopes of the Rancho Africa. This is partly due to the presence of abandoned milpas, where shrubbery forms the adventive growth, and partly to a thinning of forest trees upon the steep talus slopes that have little soil. Particularly noted was a miscellany of broad-leaved shrubs, as *Montanoa patens*, *Lantana* spp., *Urera caracasana*, *Justicia salviaeflora*, other acanthaceous spp., and the shrub *Bouvardia bouvardioides*, whose stems when cut emitted a repulsive odor. But the real subdominants upon the broken lava slopes

were stands of otate, *Arundinaria longifolia*, and under the trees *Chusquea liebmanii*. The latter bears hooks around the prominent nodes, which raked across our limbs and throats. Otate forms pure stands utilizing large areas upon the slopes and is also commonly mixed with the shrubs in open clumps under the trees. On the south slopes the more markedly drought-deciduous species prevail, with the heavy-limbed *Bursera* species, *Ceiba acuminata*, *Bombax pameri*, cacalosuche, *Plumeria rubra*, etc. There is less undergrowth. The whole formation usually continues to almost the full height of the mountain or to the foot of the last or highest volcanic rim. Northern slopes are greener with more grasses and *Chamaedorea* commonly forms small clumps among the rocks in the shade. This north-slope forest merges more quickly with the lower vanguard of the oaks.

Summit Vegetation. The top of the sierra is no more than a broken ridge sheared on every hand by high cliffs. Underbrush and large coarse grasses are rampant, which together with the broken terrain make walking difficult. Oaks are the prevailing trees, with a few small patches of pines confined to some steep northern slopes that I never succeeded in reaching. The underbrush of the mountain top, partly composed of oak rejuvenations, is largely due to the burning of the grass by the natives in the spring dry season.

Oak Forest. The dominant type of leaf in the Oak Forest is harsh; coriaceous to scabrous. The oaks themselves, the shrubs, the grasses, and even many herbs show this same character. In general throughout the Oak Forest of Western Mexico the scabrous leaf becomes, by its incessant repetition in myriad variation through many plant families, of singular interest. This leaf responds slowly to winter rains, as though reluctant to risk a few drops of guarded moisture in a transitory growth, when soon there is the long severe drought of spring to survive. There is on the whole much less Oak Forest on Sierra Tacuichamona than one would expect. The south and west areas have only a little, which is confined to small mesas and hill tops. Ill-defined remnants exist upon north exposures. East of the divide or axis, over the lower lying hills and slopes, is the best development. A scattered grove of *Erythea aculeata* was observed in that area upon a southern slope, and *Sabal rosei* grows indiscriminately upon slope and cliff and in draws.

On the northern end of the sierra around Capadero a great deal of the oak belt is occupied by harsh-leaved grasses, dominated principally by *Muhlenbergia emersleyi*, *Tripsacum lanceolatum*, and *Andropogon* and *Heteropogon* species. *Tripsacum lanceolatum* is most dominant upon the steeper slopes and the large breast-high clumps with cutting leaf-edges are serious impediments to travel. Occasionally there are stands of clumps of sacate aparejo, *Muhlenbergia gracilis* (?). The oaks are most successful on the moist shady slopes and are accompanied by a variety of shrubs, which

occasionally form thickets, all, it may be repeated, with a marked tendency to be scabrous. *Quercus albocincta, Quercus tuberculata, Quercus chihuahuensis,* and a black oak with narrow shiny leaves, *Quercus gentryi,* make up the oak family. *Bombax palmeri* from the lower cerros persists upon the arid rock rims. In the canyons many of the mesic trees and shrubs march up above the lower oaks. Over the volcanic bedrock the soil is shallow. It is mixed with broken rock and litter on the slopes. On the mesas it runs to clay. Generally it is calcareous from the leachings and metamorphism of original limestone.

Savanilla. Below the oaks, where they intergrade with Short-tree Forest trees on the north side of the mountain, is a brief expanse of Savanilla. This is a low group-dispersed formation with patches of shrubs and trees alternating with open areas of turf-like grasses, as *Bouteloua eludens* and *Cathesticum species.* The arborescent species are drawn from neighboring forest elements and make up heterogeneous mixtures, as oaks from Oak Forest, *Lysiloma divaricatum* and *Tabebuia palmeri* from Short-tree Forest. Common to this locality of Savanilla were also; *Mimosa palmeri, Lemaireocereus* sp., *Byrsonima crassifolia, Psidium molle,* and *Dodonea viscosa,* shrub Compositae, and many others. A single plant of *Fouquieria macdougali* established a southern record for the species. It is a singular habitat with a rich flora, better exampled in other localities and will be described in a later paper.

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NAJAS ARGUTA IN CENTRAL AMERICA AND ITS RELATIONSHIP TO N. WRIGHTIANA

ROBERT T. CLAUSEN

Humboldt, Bonpland and Kunth (Nov. Gen. & Sp. Plant. **1**: 298. 1815) described *Najas arguta* from Mompos in the drainage of the Magdalena River in Colombia, South America. In their description, they mentioned that

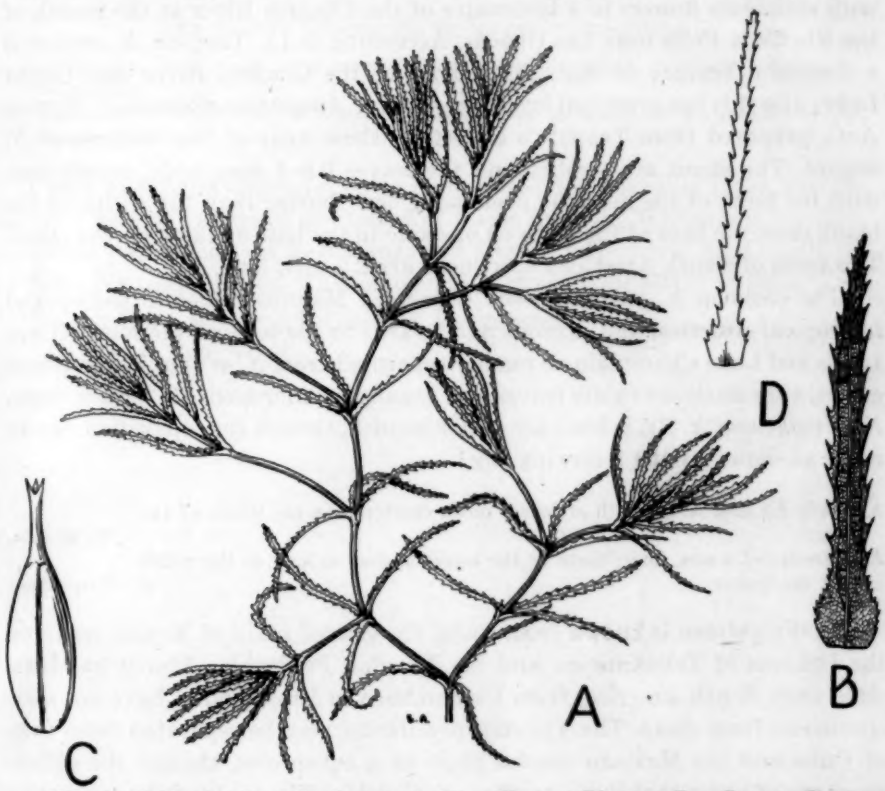

FIG. A. Habit sketch of *Najas arguta* from Chagres River at Las Guacas, Panama (×1). FIG. B. Leaf of the same specimen (×2.5). FIG. C. Staminate flower of the same (×10). FIG. D. Leaf of *N. Wrightiana* subsp. *Wrightiana* from Cuba (×2.5). Figs. A–C by Miss Elfriede Abbe and Fig. D by Miss Florence McKeel.

the leaves are strongly toothed, but they had neither flowers nor fruits. Subsequently, Schumann, in Martius, Flora Brasiliensis **3**(3): 729 (1894), described the flowers and seeds from Brazil. I have seen in the Gray Herbarium and at the New York Botanical Garden specimens collected from the Amazon

River in 1851 by Richard Spruce, no. 1622. This collection was cited by Schumann and agrees with the description of *N. arguta*. Also I have seen similar specimens from La Paila, Colombia, and others differing only in having narrower leaves, 0.6–0.8 mm. wide, from the Guayaquil River in Ecuador, *W. Jameson 544*. Specimens from Cuba identified as *N. arguta* are not that species. On the other hand, two collections from Panama are the same as South American *N. arguta* and constitute the northernmost and only known records for the species in Central America. F. C. Bishop collected it in Gatun Lake near the mouth of Gatun River, opposite Monte Lireo, on May 3, 1934. Lt. Harold Trapido, on April 5, 1945, collected, as no. B1021, many plants with staminate flowers in a backwater of the Chagres River at the mouth of the Rio Moja Polla near Las Guacas. According to Lt. Trapido, *N. arguta* is a dominant feature of the aquatic flora of the Chagres River and Gatun Lake; also it is the principal breeding place of *Anopheles albimanus*. Figures A–C, prepared from Trapido's collection, show some of the features of *N. arguta*. The stems are slender and the leaves 0.8–1 mm. wide, rarely less, with the teeth of the margins prominent, but shorter than the width of the blade from the base of the teeth on one side to the base of those on the other. The seeds of South American specimens are 2.5 mm. long.

The common *N. guadalupensis* (Spreng.) Magnus, which is widespread in tropical America, and extends northwards to the bays of the lower Great Lakes and Lake Champlain, is readily separated from *N. arguta* by its almost entire, very finely serrulate leaves and usually smaller seeds, 1–2.2 mm. long. *N. Wrightiana* A. Br. is less easy to distinguish, though the separation can be made as shown by the following key:

A. Seeds 2.5 mm. long; teeth of leaves much shorter than the width of the leaf ..... *N. arguta.*

AA. Seeds 1–1.4 mm. long; teeth of the leaves almost as long as the width of the leaves ..... *N. Wrightiana*

N. Wrightiana is known from Cuba, the coastal plain of Mexico north of the Isthmus of Tehuantepec, and the Yucatan Peninsula. Also it has been cited from South America, from Pernambuco in Brazil, but I have not seen specimens from there. The Yucatan population may be separated from that of Cuba and the Mexican coastal plain as a subspecies, though the differences are of a sort that indicate close relationship. The seeds of the two populations are similar, but the leaves differ primarily in the number of teeth along the margins and in width.

N. Wrightiana A. Br. subsp. **Wrightiana** (R. Br.) R. T. Clausen, comb. nov., based on *N. Wrightiana* A. Br., Sitzb. Ges. Naturf. Fr. Berl. p. 17 (1868). The distributional area of subsp. *Wrightiana*, as understood by me, is Cuba and the coastal plain of Mexico near Vera Cruz. A typical leaf from Cuba is shown in figure D.

N. Wrightiana A. Br. subsp. **multidentata** (Koch.) R. T. Clausen, comb. nov., based on *Naias multidentata* Koch, Ber. Schweiz. Bot. Gesell. **44**: 341 (1935). The type locality is "Forest Home," Punta Gorda, British Honduras, at an altitude of 61 m. The type, *W. A. Schipp 991,* is in the Herbier Delessert, Conservatoire Botanique de Genève. Isotypes are available in the herbarium at the New York Botanical Garden and at the University of Michigan. Other specimens of this subspecies have been collected at Uxmal, Yucatan, and Lake Peten in the Department of Peten, Guatemala. Plants from Lake Yaxha, Dept. of Peten, are more like subsp. *Wrightiana* and must be regarded as intermediate.

KEY TO THE SUBSPECIES OF NAJAS WRIGHTIANA

A. Leaves with 15–25 teeth on a margin, 0.4–0.6 mm. in width. *N.Wrightiana* subsp. *Wrightiana.*

AA. Leaves with 25–40 teeth on a margin, 0.5–0.9 mm. in width. *N. Wrightiana* subsp. *multidentata.*

I wish to express appreciation to Brother León of Havana, Cuba, for the loan of a valuable series of specimens of *Najas* from the Herbarium Savalle, Academia de Ciencias de la Habana, and from the Herbario del Colegio de La Salle, Vedado-Habana. This material has greatly aided my studies.

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BULLETIN OF THE TORREY BOTANICAL CLUB
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NOTES ON TRIFOLIUM

JAMES S. MARTIN

T. GYMNOCARPON Nutt. In 1880, Watson described *Trifolium plummerae* from northwest Nevada. He made no reference to *T. gymnocarpon* Nutt. and may not have been aware of the close relationship. According to his description, *T. plummerae* differs from *T. gymnocarpon* chiefly by its small size. Lojacano recognized the species in 1883 and included the difference of pubescence in his description but he mistakenly credited the name to Lemmon. McDermott in 1910 reduced the entity to a form of *T. gymnocarpon* but made her distinction the same as had Watson. No author since this time seems to have recognized the entity in any form. The plants in question cannot be properly distinguished from typical *T. gymnocarpon* on the basis of size, leaf shape, flowers, etc., but can be easily distinguished on the basis of leaf pubescence. Brief descriptions, synonymy, and discussion of the two entities are given below.

The species most apt to be confused with *T. gymnocarpon* is *T. lemmonii* Watson, which has, in fact, been confused by McDermott (No. Am. Sp. Trif. 194. 1910). *T. gymnocarpon* is usually a much smaller plant than *T. lemmonii*, it always has fewer flowers, and the rachis is always short, has but one to four distant whorls of flowers, and is never swollen. The flowers are often reflexed but the curvature is all in the pedicels, the base of the flower being nearly straight. *T. lemmonii* always has reflexed flowers and a part of the curvature is in the base of the flower itself, and the rachis is long and bears many close whorls of flowers.

KEY TO THE VARIETIES OF T. GYMNOCARPON

Leaflets all glabrous above.	*T. gymnocarpon* var. *gymnocarpon*.
Leaflets mostly sparingly strigose above, rarely a few leaflets of the plant glabrous on the upper surface.	*T. gymnocarpon* var. *plummerae*.

T. GYMNOCARPON Nutt. var. **gymnocarpon** (Nutt.) Martin, var. nov. *T. gymnocarpon* Nutt. in T. & G., Fl. N. Am. **1**: 320. 1838. *T. subcaulescens* Gray, Ives Rep. Colo. River Bot. 10. 1860; TYPE, *J. S. Newberry*, in pine forest near Ft. Defiance, Arizona, May 22, 1858 (on type sheet date given as May 25; Gray Herb., isotype at N. Y. Bot. Gard.). *T. nemorale* Greene, Pittonia **4**: 136. 1900; TYPE, *C. F. Baker 446*, Los Pinos (Bayfield), Colorado, May 17, 1899 (isotypes at Univ. Calif. Gray Herb., Pomona Coll., N. Y. Bot. Gard., and New Mex. A. & M.). *T. gymnocarpon* Nutt. var. *subcaulescens* (Gray) Nelson, Man. Bot. Rocky Mts., 279. 1909.

Often subcaulescent, stems rarely up to 10 cm. long; leaflets glabrous

and green above, sparingly to densely strigose and grey-green below. Flowering from April to June.

TYPE: *T. Nuttall,* "Dry hills of the Rocky Mt. Range, near the sources of the Sweetwater of the Platte," Wyoming (type at N. Y. Bot. Gard.; isotype at Gray Herb.).

Distribution: Southern Wyoming to northern Arizona and New Mexico, usually on dry hills and plains, 5500 to 9000 feet elevation.

Representative material: *C. F. Baker 161, 446; E. D. Merrill 601; A. Nelson 1230, 10205; R. C. Rollins 1669; F. Tweedy 4209; S. Watson 248.*

In the group here considered two entities have often been recognized, *T. gymnocarpon* and *T. subcaulescens.* There are some slight differences

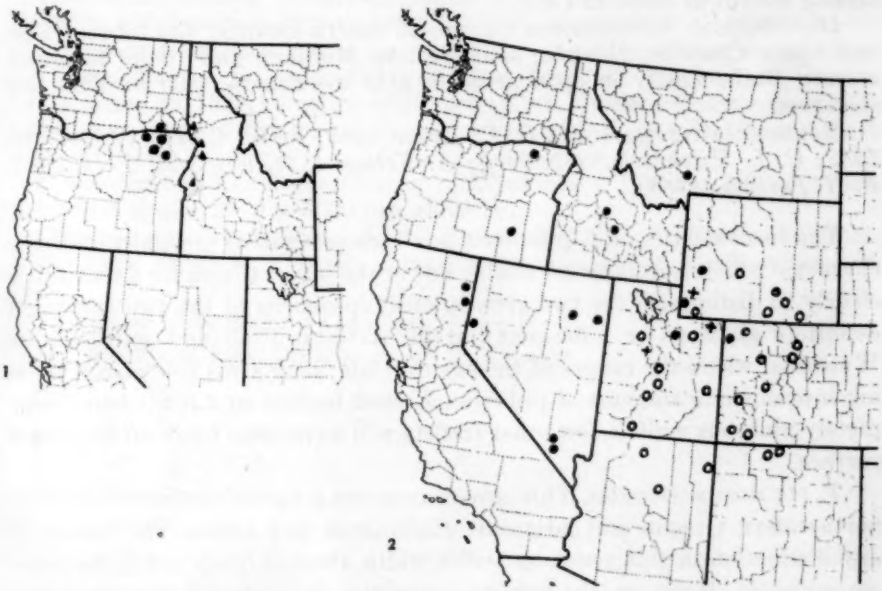

FIG. 1. Distribution of *T. plumosum:* dots, *T. plumosum* var. *plumosum;* triangles, *T. plumosum* var. *amplifolium.* FIG. 2. Distribution of *T. gymnocarpon:* circles, *T. gymnocarpon* var. *gymnocarpon;* solid dots, *T. gymnocarpon* var. *plummerae;* crosses, intermediates between these two varieties.

between these two. Plants from Wyoming (including the type of *T. gymnocarpon*) and central Utah usually have short flowers from 7.5 to 10 mm. long, while the flowers of plants from Colorado, New Mexico, and Arizona (including the type of *T. subcaulescens*) are mostly from 10 to 13 mm. long. To a slight extent, the amount of pubescence is correlated with the flower length. Northern plants are usually sparsely strigose, while southern plants are more thickly strigose, the most heavily pubescent plants being those from New Mexico. However, these characters do not appear to be sufficiently sharp to warrant recognition for the two entities.

T. GYMNOCARPON Nutt. var. **plummerae** (Wats.) Martin, var. nov. *T. plummerae* Watson, Bot. Calif. **2**: 440. 1880. *T. plummeri* Lemmon ex Lojac. Nuov. Giorn. Bot. Ital. **15**: 162. 1883, based on the same type as the preceding, probably not intended as a new description and erroneously ascribed to Lemmon. *T. gymnocarpon* Nutt. f. *plummerae* (Wats.) McDerm. N. Am. Sp. Trif. 192. 1910.

More usually caespitose than the typical variety; leaflets strigose and grey-green below, lighter green and less densely (but always noticeably) strigose above. Flowering in May and June.

TYPE: *J. G. Lemmon & S. A. Plummer*, Peaks above Pyramid Lake, Nevada, May 15, 1879, elev. 6000 feet (Lemmon's name only on labels, letter with type sheet says Plummer assisted with the collecting; type at Gray Herb.; isotype at Univ. of Calif.).

Distribution: Northeastern Oregon to Sierra County, California; Elko and Clark Counties, Nevada; southwestern Montana and Idaho to northeastern Utah, mostly in open areas in arid woodlands, 4800 to 9500 feet elevation.

Representative material: *C. C. Bruce 2293; I. W. Clokey 7561, 7782, 7983; C. L. Hitchcock 8832, 9470; A. Nelson 4521, 9018; M. Peck 2325; R. H. Peebles 13956.*

The two varieties of *T. gymnocarpon* here recognized are separated on a character which is usually unreliable but in the present instance seems fairly clearly to distinguish the two groups. Most specimens of the two are either definitely glabrous or pubescent but in northern Utah and southwestern Wyoming, where the ranges of the two overlap, there are a few plants showing intermediate amounts of pubescence, most leaflets on a plant being completely glabrous while a few other leaflets will have some hairs on the upper surface.

T. PLUMOSUM Douglas. This species occupies a rather restricted range in northeastern Oregon and adjacent Washington and Idaho. The basing of any distinction in this genus on leaflet width alone is likely not to be taken too seriously. However, the present separation is solely on that character. While the number of specimens examined is not large, the difference in width of leaflets and the distinctive geographical separation on the two sides of the Snake River Canyon are thought to be sufficiently marked to merit some separation of the two groups of plants.

KEY TO THE VARIETIES OF T. PLUMOSUM

Leaflets of the basal leaves 2–5 (7) mm. wide, apices slender, acuminate, apiculate. *T. plumosum* var. *plumosum.*

Leaflets of the basal leaves (8) 9–16 mm. wide, apices broader, acute, apiculate. *T. plumosum* var. *amplifolium.*

T. PLUMOSUM Dougl. var. **plumosum** (Dougl.) Martin, var. nov. *T. plumosum* Dougl. in Hooker, Fl. Bor. Am. **1**: 130. 1840.

Leaflets mostly narrowly linear, usually folded, falcate, with slender

acuminate apices, those of the basal leaves 2–5(7) mm. wide, of the upper leaves sometimes a little wider. Flowering in June and July.

TYPE: *D. Douglas*, Blue Mountains, Oregon or Washington (not seen).

Distribution: Walla Walla County, Washington, to Union County, Oregon, on dry sagebrush slopes and in open pine woods, 2000 to 4000 feet elevation.

Representative material: *W. C. Cusick 459, 2348, 3345; D. D. Keck 3585; W. R. Moore 162; M. E. Peck 7710, 10438, 17436.*

T. PLUMOSUM Dougl. var. **amplifolium** Martin, var. nov.

Leaflets broader, elliptical, often folded and falcate, those of the basal leaves 8–16 mm. wide, of the upper leaves sometimes slightly narrower, apices acute, but not slenderly acuminate. Flowering in June and July.

(Foliolae latiores, ellipticae, saepe complicatae et falcatae, foliolis foliorum inferiorum 8–16 mm. latis, foliorum superiorum aliquando leviter angustioribus; apicibus acutis, apiculatis, autem non graciliter acuminatis.)

TYPE: *Marcus E. Jones 6254*, Salmon Meadows, Washington County, Idaho, June 22, 1899, elevation 4000 feet (Herb. Pomona College no. 27373; isotypes at Univ. of California, Stanford Univ., N. Y. Bot. Gard., and Univ. of Washington).

Distribution: Nez Perce County to Washington County, Idaho, on dry sagebrush slopes, 2000 to 5000 feet elevation.

Representative material: *A. A. Heller 3398; L. F. Henderson 2729; G. N. Jones 4976; M. E. Jones, 6354; B. Maguire 17294; C. W. Sharsmith 3619.*

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THE EVALUATION OF SOME TAXONOMIC CHARACTERS OF CULTIVATED BRASSICA WITH A KEY TO SPECIES AND VARIETIES—II. THE KEY[1]

VON GEE SUN

DISCUSSION

The merging of *Brassica pekinensis* Rupr. with *B. chinensis* L. is in agreement with the botanical facts. Since the writer has found no hybrid vigor in the F_1 of *B. chinensis* var. *pandurata* Sun (siao-yu-tsai) × *B. pekinensis*, and no distinct morphological difference between these except in the foliar organs, *B. pekinensis* may reasonably be regarded as a race closely related to *B. chinensis*. Although Tsen and Lee (1942) pointed out seven important characters for differentiating these two species, it is the writer's opinion that most of them are of minor importance. For example, Tsen and Lee stated, first, that *B. chinensis* is biennial and *B. pekinensis* is annual; but the writer has observed in Meitan that when they are sown in the early fall or late summer, both become marketable in early winter and set seeds next spring. Secondly Tsen and Lee state that, given cool moist soil, *B. chinensis* tends to make a turnip-like root, while the root of *B. pekinensis* is normal; according to the writer's observation turnip-like roots are found only rarely in *B. chinensis*, being uncommon in all varieties. Thirdly, a few setose hairs on the ribs of *B. pekinensis* as compared with glabrousness of *B. chinensis* may be regarded as a minor difference, for *B. chinensis* var. *pandurata* also has a few setose hairs on the ribs and leaf-blade. Fourthly, head formation in *B. pekinensis*, though typical, is subject to environmental modification and is often artificially brought about. Tsen and Lee also noted in their paper that growers used to tie the outer leaves together with straw or other materials and bank the soil over the lower part of the plant in order to obtain solid heads. Fifthly, Tsen and Lee pointed out that *B. chinensis* is commonly grown in the South and *B. pekinensis* is mostly cultivated in the North. Though this statement is generally true, the writer has found that its cultivation is not uncommon in Chekiang, Szechuang, Kweichow, and Yunnan.

For these reasons the writer does not consider the above five points as taxonomically important. The only big difference between *B. pekinensis* and *B. chinensis* is found in their foliar organs. Tsen and Lee summarized the characters of *B. chinensis* as follows: blade large, light green to yellowish-green, heart leaves yellowish-white, thin, veiny, crinkled, undulate,

[1] The first part of this paper appeared in Bull. Torrey Club **73**: 244–281.

and sometimes indistinctly and irregularly dentate, without distinct petiole but with a flat, whitened, long base, 2–8 cm. wide, margined by a wide, thin, notched or jagged wing. The writer is in full accord with the above statement and would call attention further to the foliar morphology of Meitan siao-yu-tsai (*B. chinensis* var. *pandurata*), which, in his opinion, may be regarded as an intermediate race between *B. chinensis* and *B. pekinensis*. In this connection, it may be important to remind oneself of the general botanical principle that the characters of reproductive organs are more significant than those of vegetative organs. Not only is the development of the latter subject to environmental changes, but the characters of reproductive parts are comparatively more stable than those of other parts.

The distinguishing characteristics of *B. alba* Rabenh. (*Sinapis alba* L.) should be emphasized. They are as follows: (1) number of chromosomes and size of pollen grains; (2) size and shape of silique; (3) number of seeds per silique; (4) shape and length of beak; (5) hairiness of silique and of the entire plant; and (6) the furrowed stem. Since in none of these characters does this species agree with any other species of this group, the writer finds it difficult to agree with those who suggest combining the two genera *Brassica* and *Sinapis*. The phylogenetic relation between *Sinapis alba* and the species of *Brassica* proper should be of great taxonomic importance. For a study of this problem interspecific crosses were made in 1943, *Sinapis alba* being used as a common parent; the writer failed to obtain a single true hybrid seed.

It is of interest to observe that there is a parallelism in many characters between *B. nigra* and *B. juncea*, between *B. nigra* and *B. carinata*, between *B. oleracea* and *B. carinata*, between *B. oleracea* and *B. napus*, between *B. chinensis* and *B. napus*, and between *B. chinensis* and *B. juncea*. *B. nigra* has sepals wide-spreading and silique 4-sided and closely appressed to the rachis, which is strongly reminiscent of those of *B. juncea* var. *orthocarpa*. *B. carinata* has the same 4-sided silique as *B. nigra*, and both have a very short beak. The inflorescence of *B. carinata* is extremely elongated and open at anthesis, i.e., the opened flowers or unopened buds are widely distributed on the rachis, which is the typical character of *B. oleracea*. Both *B. chinensis* and *B. napus* have a very long beak, clasping stem-leaves, and corymb-like inflorescence with the flowers clustered at the top. Both *B. chinensis* and *B. juncea* have corymb-like short infloresences with flowers clustered at the top, and small petals.

According to the experimental results of Morinaga and U, Brassica naturally falls into six groups. The writer accepted their suggestion at the beginning and tried to combine into a single species all varieties and species having the same chromosome number. After a critical examination of the present materials, he found this impossible. Although *B. campestris* var.

oleifera and *B. chinensis* var. *pandurata* both belong to the same 10-chromosome group, it is easy to recognize most of the important differences between the two races. For instance, *B. campestris* has glaucous-green, distinctly pubescent radical leaves, very small petals, a petal claw not abruptly constricted, and a short silique; while *B. chinensis* var. *pandurata* has non-glaucous light green leaves with but few setose hairs on the midrib or blade, petals rather large and orbicular with an abruptly constricted but very short claw, and a large and long silique.

By an inspection of the varieties within these two species, one can realize that the horticultural variation of turnip varieties within the European 10-chromosome group has never been found in China; and the large number of horticultural varieties within the oriental 10-chromosome group, such as wu-ta-tsai and hwang-ya-tsai, has never been found in the western Old World. It is clear that two secondary centers of species-formation of the 10-chromosome *Brassica* have been differentiated by ecological and geographical agencies. As Vavilov wrote in 1940, after many years of collective studies on the most important cultivated plants, aided by cytologists, geneticists, physiologists, anatomists, and immunologists, we are coming to the concept of a Linnean species as a definite, discrete, dynamic system differentiated into geographical and ecological types and sometimes comprising an enormous number of varieties.

In *Gossypium* the same principle suggests a similar taxonomic system. For example, both *G. herbaceum* L. and *G. arboreum* L. have 13 haploid chromosomes, but definite dissimilarities have been found between these two species; and *G. arboreum* is distributed mostly in the eastern part of Asia, while *G. herbaceum* is confined to the western part of Asia, Africa, and the eastern part of Europe. Both *G. hirsutum* L. and *G. barbadense* L. have 26 haploid chromosomes, but they also exhibit great dissimilarities, and *G. hirsutum* is distributed in Central and North America, while *G. barbadense* is confined to the West Indies and South America.

In accordance with the above statement, the writer suggests dividing the 10-chromosome *Brassica* into two geographical races, one oriental and the other western. The oriental race is distributed in China and Japan and should be known by the old name *B. chinensis*. The distribution of the western race is mainly in Europe and it should be known by the old name *B. campestris*.

KEY TO SPECIES AND VARIETIES OF BRASSICA

A. Silique short, 11–30 mm., the beak short, 2.87–3.60 mm. *See* AA, *p. 373*, and AAA, *p. 374*.

B. Stem and leaves of young seedlings densely pubescent, the mature plant prominently hispid-hairy, the inflorescence short at anthesis, the flowers clustered corymbosely, the petals very small (mean length 7.55–8.95 mm.), silique very small (mean length 11.02–11.20 mm.); seeds per silique 3–8 (mean 4.6–5.6). 1. *B. nigra* Koch.

BB. Plant glabrous; inflorescence elongated at anthesis; flowers and buds widely distributed on the rachis; flowers medium large, the petals 13.75–15.97 mm. long; silique medium small (mean length 29.3–30.05 mm.); seeds per silique 5–18 (mean 11.2–11.9). 2. *B. carinata* Braun.

AA. Silique long (mean length 48.55–71.4 mm.), not 4-sided; plant glaucous-blue or blue-green (varying to red in horticultural varieties); flowers medium to large, mean petal length 11.2–23.9 mm.; petals light yellow, ochroleucous, cream-yellow, or rarely white, long-tapering to narrow bases.

B. Inflorescence elongated at anthesis; flowers large, the mean petal length 20.8–23.9 mm., the sepals mostly firmly erect and not spreading, often somewhat saccate at the base; pollen small (mean length 32.96–37.01 μ); beak medium short (mean length 6.9–11.3 mm.); mostly with thickened edible parts.

C. Stem of the first year elongated.

D. Stem branched and leafy, the leaves long-petioled, those of some kinds curled. 3a. *B. oleracea* var. *acephala* DC.

DD. Stem unbranched, the axillary buds arrested and swollen, bearing in the axils little edible heads or "sprouts" about 2.5 cm. in diameter; leaves short and broad, about as broad as long, often with ear-like lobes at the base. 3b. *B. oleracea* var. *gemmifera* Zenker.

CC. Stem of the first year short.

D. Stem thickened and tuberlike above ground; leaves relatively small, thinner, those on the flowering stem slender-petioled. 3c. *B. oleracea* var. *gongyloides* L.

DD. Stem not thickened nor tuberlike.

E. Terminal bud arrested, forming a compact head; inflorescence not normally developed the first year; leaves large, often 30 cm. across, oblong-obovate to nearly circular, little if at all lobed at the base, the stem-leaves variously clasping. 3d. *B. oleracea* var. *capitata* L.

EE. Terminal bud not arrested; inflorescence partly developed the first year.

F. Inflorescence compressed, forming a compacted mass of short, thickened, colorless peduncles, pedicels, bracts, and undeveloped flowers; leaves long-oblong or elliptic, strongly ascending. 3e. *B. oleracea* var. *botrytis* L.

FF. Inflorescence not compacted, but grown for the thickened flower-shoots that arise from the leaf-axils, making a more or less open and variously aborted panicle. 3f. *B. oleracea* var. *italica* Plenck.

BB. Inflorescence short at anthesis, the flowers clustered corymbosely at the top; flowers medium large, the mean petal length 11.2–15.325 mm., the sepals not firmly erect but rather separating from the petals; pollen large (mean length 39.97–42.0 μ); young radical and heart leaves bearing a few translucent setae on the ribs.

C. Beak long (mean length 16–17.3 mm.); root neither tuberlike nor thickened, mostly in the form of a straight tap-root; radical leaves long-petioled, oblong-obovate with small lobes on the lower part; stem-leaves oblong-lanceolate, toothed and notched but seldom lobed, mostly clasping. 4a. *B. napus* var. *oleifera* E. & G.

CC. Beak medium short (mean length 11.2–11.7 mm.); root large and tuberlike with a neck, branching more or less from the lower sides; radical leaves similar to those of No. 4a; stem-leaves with a large terminal lobe with 1 or 2 pairs of smaller lobes at the base, and often leaf-fragments on the petiole-like contraction, commonly clasping. 4b. *B. napus* var. *napobrassica* (L.) Petr.

AAA. Silique medium to medium long (mean length 19.1–53.7 mm.); inflorescence short at anthesis, the flowers corymbosely clustered at the top; flowers medium small, the mean petal length 7.63–13.2 mm., the petals yellow or cream-yellow to cream-white.

B. Sepals separating from the petals; pollen small (mean length 32.4–39.92 μ); petals less prominently tapering; plant green, dark green, or light green to yellowish-green, occasionally purple, only thinly or not at all glaucous; leaves glabrous to more or less sparsely setose-hairy on the ribs or veins.

C. Plant mostly glaucous-green, distinctly pubescent, bearing translucent setae on ribs and leaf margin; cluster of radical leaves not greatly developed nor of long standing but spreading over the ground.

D. Root not enlarged nor tuberlike, usually shallow and branching and not forming a straight, developed tap-root; stem-leaves sessile, auriculate-clasping; basal and lower stem-leaves variously lyrate toward the base, having a long terminal lobe and several pairs of small lobes; often known as a weed. 5a. *B. campestris* var. *oleifera* E. & G.

DD. Root characteristically large, softish, tuberlike, without neck; radical leaves petioled, deeply cut into small lobes at the base, with a large terminal lobe above; stem-leaves mostly denticulate, variously clasping but not auriculate. 5b. *B. campestris* var. *rapifera* Metz.

CC. Plant green, occasionally purple, mostly non-glaucous, a few slightly glaucous; leaves glabrous to sparsely setose-hairy on the ribs or veins; cluster or radical leaves often greatly developed for domestic uses; leaves usually entire, occasionally with a few teeth along the base of the midrib.

D. Stem-leaves clasping.

E. Radical leaves broad, light green to yellowish-green, prominently winged along both sides of the midrib, sparsely covered with setose hairs on the under side of the midrib.

F. Radical leaves yellowish-green, crinkled, their petioles very broad, flat, tooth-winged; heart leaves deficient in chlorophyll, closely folded to form a compact head. 6a. *B. chinensis* var. *pekinensis* (Rupr.) Sun.

FF. Radical leaves light green or purple, neither crinkled nor deficient in chlorophyll, pandurate or fiddle-shaped to oblong-ovate, sometimes the lower part of the wing lobed or wanting, the petioles narrow and thin. 6b. *B. chinensis* var. *pandurata* Sun.

EE. Radical leaves not winged, glabrous, light to dark green, occasionally glossy or slightly glaucous, the petioles thick, broad, and succulent.

F. Radical leaves ovate to oblong-ovate, green to light green, the petioles white or greenish-white, standing upright from the ground. 6c. *B. chinensis* var. *communis* T. & L.

FF. Radical leaves numerous, well spread on the ground in a broad rosette 50 cm. in diameter, dark green, glaucous, curved outward to some extent, the blades broad-ovate or suborbicular in outline, distinctly marked with a number of veins, the petioles greenish-white, scarcely bearing leaf-fragments. 6d. *B. chinensis* var. *rosularis* T. & L.

FFF. Radical leaves shiny dark green, entire, glabrous, the petioles thick, broad, succulent, white or greenish-white, not winged, the blades orbicular, usually curved inward with a pair of small auriculate leaflets below, standing upright in the winter, but spreading over the ground before anthesis; petals creamy white. 6e. *B. chinensis* var. *albiflora* Sun.

DD. Stem-leaves non-clasping, long and narrow, sessile, with expanded base; radical leaves not prominently winged, long-oblanceolate, very slender, the midribs narrow and thin, the blades sometimes curved inward. 6f. *B. chinensis* var. *angustifolia* Sun.

BB. Sepals wide-spreading; pollen large (mean length 39.52–46.72 μ); petals prominently tapering toward the base; plant green or light green to yellowish-green, occasionally purple, only thinly or not at all glaucous; mature leaves glabrous; young leaves glabrous to more or less sparsely setose-hairy on ribs or veins; shape various; stem-leaves non-clasping.

C. Root oblong, plump, tuberlike, more or less cylindric, broad and truncate at both ends, with a well marked hypocotyl or neck at the upper part, a profusion of laterals widely diffused at the base; plant glaucous-green; leaf outline various; petioles short. 7a. *B. juncea* var. *megarrhiza* T. & L.

CC. Root not tuberlike.

D. Lower part of the stem thickened, shortened, the nodes and the base of the rudimentary petioles enlarged, swollen, forming a nodule-like or horn-like edible structure; leaves various. 7b. *B. juncea* var. *tsatsai* Mao.

DD. Lower part of the stem neither thickened nor shortened, no nodule-like structure developed.

E. Petioles of radical leaves short and stout.

F. Radical leaves strongly developed, the blade large and broad, usually 30–60 cm. long, more or less hairy when young, entire, angled, or with fine teeth along the margin, almost sessile, the lower part of the midrib broad, attaining 7.5 cm. or more in width, the blade obovate to oval in outline; upper stem-leaves oblong to lanceolate, usually sessile or tapering toward the base. 7e. *B. juncea* var. *rugosa* Bailey.

FF. Radical leaves strongly developed, the blade crisped, curled, and fringed. 7d. *B. juncea* var. *crispifolia* Bailey.

FFF. Radical leaves multifid into many linear or filiform lobes or shreds which conform to the veins. 7c. *B. juncea* var. *multisecta* Bailey.

EE. Petioles or midribs of the radical leaves long, narrow, and thin.

F. Radical leaves long and narrow, oblanceolate, obtuse; blades neither notched nor lobed but evenly dentate; very low-branched. 7f. *B. juncea* var. *oblanceolata* Sun.

FF. Leaves linear; upper stem-leaves almost without blades; terminal part of the radical leaves entire, the basal part variously notched; stem weak, branching low. 7g. *B. juncea* var. *linearifolia* Sun.

FFF. Radical leaves long-petioled; blades obovate to oval, prominently tapering toward the base, a large obtuse terminal lobe above and several small lobes on the lower part.

G. Mature silique standing away from the rachis at an angle of about 45°; branching medium to high. 7h. *B. juncea* var. *gracilis* T. & L.

GG. Mature silique erect, closely appressed to the rachis, forming an angle of about 15° with it; branching high (the lowest branch measured 96 cm. above ground). 7i. *B. juncea* var. *orthocarpa* Sun.

SUMMARY

A large number of morphological characters of different species of *Brassica* have been investigated and their taxonomic importance evaluated.

Parallelism in many characters between certain species has been pointed out. A revised key to the species and varieties is presented. The following species are recognized: *B. nigra* Koch, *B. carinata* Braun, *B. oleracea* L. (6 vars.), *B. napus* L. (2 vars.), *B. campestris* L. (2 vars.), *B. chinensis* L. (6 vars.), *B. juncea* Coss. (9 vars.). *Sinapis alba* L. is not considered a species of *Brassica*. *B. pekinensis* Rupr. is merged with *B. chinensis* L.

ADDENDUM

In the course of typing this paper, the writer has found the paper of Sabnis and Phatak (1935) on the classification of cultivated Indian mustards. These authors divide *B. juncea* into two races based on hairiness, and divide *B. campestris* also into two races based on the position of the silique on the rachis. Although the writer has not examined their material, some points should be emphasized after an inspection of their descriptions. I doubt whether the silique of *B. campestris* var. *erectisiliquosa* is as erect as that of *B. nigra;* otherwise the appressed-silique character will not be confined to the 8- and 18-chromosome species. Since there is no definite borderline between petal-claw and petal proper, I insist on including the claw in the length of the petal. Sabnis and Phatak determined the silique length by including beak and pedicel. Because the beak length varies in the different species used, the results obtained by Sabnis and Phatak fail to represent the true length of the silique proper.

ACKNOWLEDGMENTS

The writer wishes to express his grateful thanks to Professors and Doctors Tsung-Le Loo and Feng C. Loo for their valuable criticisms and assistance in the preparation and revision of the manuscript. The writer would also extend his appreciation to Mr. Y. M. King and S. Wang, senior and sophomore students of Agronomy respectively, by whom all drawings included in the first part of this paper were prepared.

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BULLETIN OF THE TORREY BOTANICAL CLUB

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TORREYA

BOOK REVIEW

A Catalog of Illinois Algae. By Max E. Britton. i–viii, 1–177. Evanston: The Graduate School, Northwestern University. 1944. $3.00.

The botanical literature of the state of Illinois has been enriched by the contributions of some of the most active algologists in this country. A noteworthy first step, largely bibliographic, in summarizing to date the knowledge of Illinois algae obtained from both published and unpublished data, is presented in this book. The literature containing algological data is conveniently divided into five groups based on the type of investigation involved: taxonomic and floristic studies, general ecological and pollution studies, studies of algae as animal food supply, monographs and other comprehensive reports, miscellaneous papers. From this literature the information contained in the catalog was obtained. For the most part the scheme of classification found in G. M. Smith's "Freshwater Algae of the United States" is followed. The species are listed alphabetically within each group. Following the name of a species a reference is given indicating a modern authority for the validity of the species and furnishing a readily available means of finding modern descriptions and other information written, as far as possible, in the English language. There are 178 genera including 962 species, varieties and forms.

It is stated that plans are being made to extend this summary survey in subsequent reports to include descriptions, keys, illustrations and habitat analyses for the algal groups growing in Illinois. Algologists will look forward to these reports with great interest.—JEROME METZNER.

FIELD TRIP REPORTS

MARCH 24. THE NEW YORK BOTANICAL GARDEN. A study of three lines of fern descent was made, first from the literature available, through the courtesy of Miss Elizabeth Hall, Librarian, and followed by an examination of fossil forms in the paleobotanical collection in the basement of the Museum Building. The group then journeyed to the fern house in the conservatory range and continued the study by examining the living forms there. Mr. Milton Gallub, Horticulturist in the fern house, assisted and answered questions about fern propagation. Attendance 28. Leader, Mrs. Gladys P. Anderson.

The success of this trip has led to a suggestion for similar studies of other groups, particularly tropical plants during the winter months. If this sounds interesting please notify the field chairman and plans will be made.

MARCH 31. POINT PLEASANT, N. J. A beautiful spring day. Waterfowl scarce owing to their heading northward two weeks or so in advance because of mild weather. The blue-winged teal was the best bird of the day. Also observed were: pied-billed grebes, great blue heron, baldpate and scaup ducks, ospreys, coots, great black-backed, herring and ring-billed gulls, rusty blackbird and sharp-tailed sparrows. Total species 32. Attendance 12. Leader, David Fables.

APRIL 13. BOYCE THOMPSON INSTITUTE FOR PLANT RESEARCH, YONKERS, N. Y. The group first visited the research project on aeration of deep cultures for citric acid pro-

duction. Controlled production of test flies and the testing of efficacy of substances for knock down and killing of flies was demonstrated. The means of testing fungicides and insecticides as plant sprays, and dusts were then considered. A greenhouse heated entirely by light, sunlight or artificial, was displayed with plants growing thriftily. The laboratory for research in the nature and structure of viruses had prepared a very interesting exhibit as had two laboratories where growth regulating substances are being studied. The tour of the laboratories ended in the seed research rooms. A time lapse, kodachrome movie of growth, notably the development and opening of flowers, was shown in the conference room. Leaders, Dr. Zimmerman and Dr. Arthur. Attendance 19.

April 14. Southfields, N. Y. A walk over the Nurian and some other trails for lichens particularly. Over 70 species were recorded. No additional plants in flower were added to the list of last week. A rather copious amount of *Buxbaumia* was observed. Attendance 10. Leader, G. G. Nearing.

April 21. Windbeam Mt., Midvale, N. J., for lichens and fungi. "Only four of us turned out, religion getting the better of nature." Leader, G. G. Nearing.

April 28. Succasunna, N. J. Joint outing with Mountain Lakes Garden Club, led by Mrs. E. H. Kocher. "*Helonias* in flower and an acre of the rare cuckoo flower, *Cardamine pratensis.*" Attendance 22. Our leader, G. G. Nearing.

April 28. Audubon Nature Center and Fairfield Connecticut Garden. Weather was cloudless, cool and ideal for walking. A list of 21 birds was compiled in exploring 5 of the pleasant Trails provided. Eighty-seven plants were listed, with *Shortia galacifolia* providing the thrill of the day. Wild, cultivated, and naturalized species were given equal consideration. The Fairchild Connecticut Gardens have been taken over by the adjacent Audubon Nature Center and Mr. L. J. Bradley, of the Connecticut Botanical Society, has been made Director. His job for this year is to restore the Gardens. Mr. Bradley assisted in conducting the trip and invited us to return at any time.

Mr. William Schneider, Jr., has made an interesting comparison of this trip with that of two years ago. In 1944 the trip was on May 28, a month later. Twenty species of birds were listed yet the two lists have only seven species in common. We wonder if the group went out for exotics in 1944. Blue jays, crows, and robins, missing from that list, are such large birds! Leader, Mrs. Henrietta Dotson. Attendance 8.

News Note

The privately owned and privately managed new Desmond arboretum at Newburgh, New York, temporarily closed during the war period, will from now on be open again, daily, free of charge, to interested visitors.

Those wishing to inspect this arboretum, which, among other attractions, has a lovely view of the Hudson River looking down through the Highlands of the Hudson toward West Point, can obtain permission by writing or calling at the office of New York State Senator Thomas C. Desmond, 94 Broadway, Newburgh, New York, or by getting in touch with Arboretum Superintendent Rudolph M. Nocker.

The arboretum, started in 1939, now contains 499 species of trees and shrubs. Senator Desmond is endeavouring to include in this arboretum all native American trees and shrubs which may prove hardy in the Newburgh, New York, climate, together with some of the more interesting or more ornamental foreign trees and shrubs.

Proceedings of the Club

Minutes of the Meeting of November 20, 1945. The regular meeting of the Torrey Botanical Club was called to order by President Seaver at the Brooklyn Botanic Garden at 3: 40 p.m. with 8 members and friends present. The minutes were approved as read.

There was no business and the meeting was turned over to Dr. A. H. Graves who spoke on the "Effects of an Unusual Spring." The speaker's abstract follows:

"In the northeastern U. S. the unusually warm early spring of 1945, followed by a cold wet period, lasting well into May, was the primary cause of serious troubles with native and cultivated trees and shrubs. First, there was much winter killing, which we should prefer to call "spring scorch." Next, a late April frost killed many flowers and flower buds—in Massachusetts, 80–90 per cent of the flowers of all fruit trees were killed. Fortunately the New York City region and New Jersey escaped these killing frosts. Again, because of continued, soaking rains and low temperatures, there was much root suffocation, resulting in root rot. The symptoms of this trouble, in early May, were similar to those of spring scorch, but the primary cause was different. The Sycamore blight, induced by *Gnomonia veneta*, was unusually destructive, but fortunately was confined almost entirely to the native species—*Platanus occidentalis.*"

After discussion and questions the meeting was adjourned at 4: 30 for tea which was served by the Garden staff.

Respectfully submitted,
FRANCES E. WYNNE,
Recording Secretary

Minutes of the Meeting of December 4, 1945. The regular meeting of the Torrey Botanical Club was called to order by President Seaver at Columbia University at 8: 45 p.m. There were 35 members and friends present. The minutes were approved as read.

The scientific program of the evening consisted of a very interesting paper by Dr. R. S. deRopp, "Growth of Normal and Malignant Plant Tissues in Vitro." After considerable discussion, the meeting was adjourned for tea at 9: 30.

Respectfully submitted,
FRANCES E. WYNNE,
Recording Secretary

Minutes of the Meeting of December 19, 1945. The regular meeting of the Torrey Botanical Club was called to order by President Seaver at 3: 45 p.m. at the New York Botanical Garden with 15 members and guests present.

There were six persons elected to annual membership, one to associate membership, and four resignations were accepted with regret.

The scientific program of the afternoon was an illustrated paper by Dr. Aubrey W. Naylor, "Problems in Nitrogen Fixation." After discussion, the meeting adjourned for tea at 5: 00 p.m.

Respectfully submitted,
FRANCES E. WYNNE,
Recording Secretary

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